



Evolving Climate in the NWS' Weather-Ready Nation National Climate Services Meeting

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NOAA Assistant Administrator for Weather Services

National Climate Services Meeting- Silver Spring, MD

May 9, 2016



Outline

- **Building a Weather-Ready Nation**
- **Restructuring NWS Budget, HQ, Governance: What Does it Mean to You?**
- **Improving Climate Prediction**
 - **Addressing the Climate-Weather “Grand Challenges”**
 - **Embracing the Multi-Model Approach to Numerical Climate Prediction**

Increase in Extreme Events

“Average” Year and Trends in the U.S.



650 Deaths
\$15B in Losses



26,000 Severe
Thunderstorms



6 Atlantic Basin
Hurricanes



1,300 Tornadoes



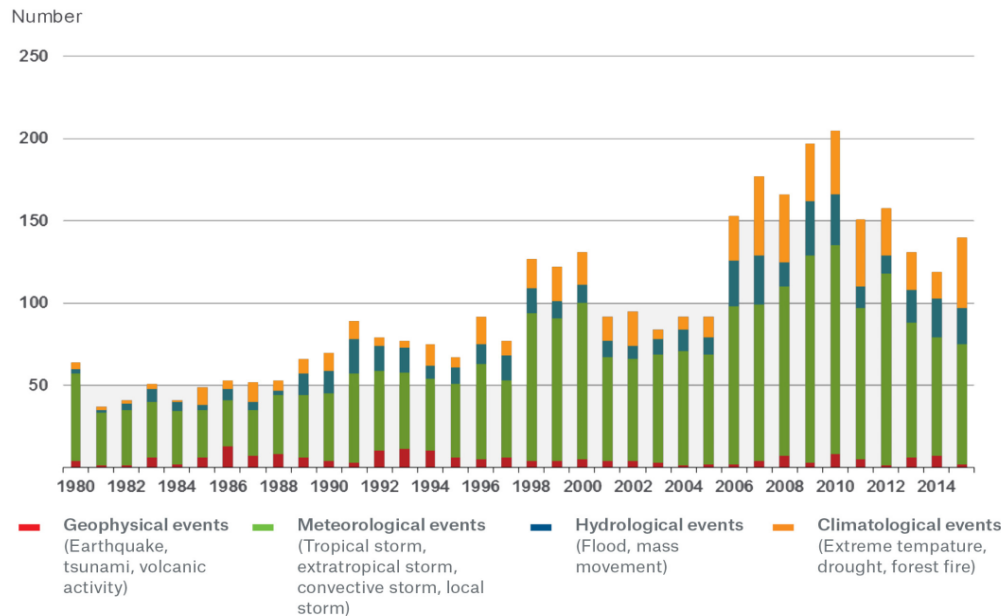
5,000 Floods

Munich Re NatCatSERVICE

Loss events in the U.S. 1980 - 2015

Number of events* *Excludes last week of December 2015

Munich RE 



© 2016 Münchener Rückversicherungs-Gesellschaft, Geo Risks Research - As at January 2016

Increasing Vulnerability

- Increasing population
 - More infrastructure at risk
 - Signs of sea level rise
-
- Improved forecasts of extreme events 4-8 days in advance
-
- Connecting forecasts to decision-makers is basis for building a Weather-Ready Nation

NWS Strategic Outcome: A Weather-Ready Nation

Becoming a Weather-Ready Nation is about building community resiliency in the face of increasing vulnerability to extreme weather, water and climate events

“Ready, Responsive, Resilient”

- **Requires NWS to produce:**
 - *Better forecasts and warnings*
 - *Consistent products and services*
 - *Actionable environmental intelligence*
- **NWS needs to address the “last mile” that connects forecast to critical national, state and location decisions**
 - *Provide Impact-based Decision Support Services (IDSS)*
 - *Deliver through multiple and reliable dissemination pathways*
 - *Work with partners, including embedding NWS in Emergency Operations Centers and incorporating Social Sciences, to gain public’s needed response*



Involves entire US Weather, Water and Climate Enterprise WORKING TOGETHER to achieve national preparedness for weather, climate and water events

NWS Strategic Outcome: *Weather-Ready Nation*

NWS Strategic Goals

- Improve Weather Impact-Based Decision Support Services
- Improve Water Forecasting Services based on “Total Water Prediction”
- Enhance Climate Services and adapt to climate-related risks
- Improve sector-relevant information in support of economic productivity
- Enable environmental forecast services supporting healthy communities and ecosystems
- Sustain a highly skilled, professional workforce equipped with training, tools, and infrastructure to meet mission

Interdisciplinary/Collaborative



August 2014 – Harmful Algal Bloom

Prediction is what makes NOAA/NWS unique and indispensable

What Does it Mean to the NWS?

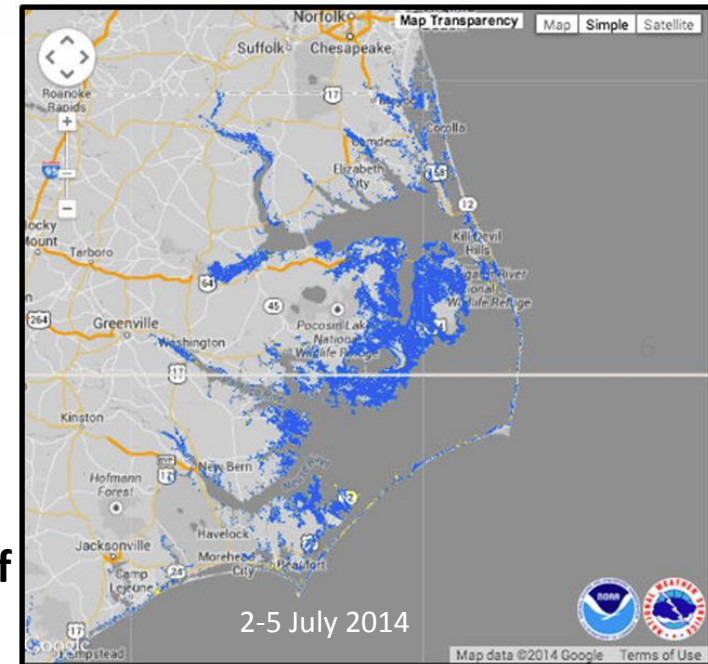
**Building a Weather-Ready Nation will change the way we work–
and change the nature of our products:**

- Becoming more oriented toward Earth System Sciences (atmosphere, ocean, land, cryosphere)
- Social Science - ensure message delivered = message received for desired outcomes (e.g. How to describe and display “storm surge?”)
- Understanding decision makers and their “shifting risk preferences” before/during/after an event
 - “Organized” – Government
 - “Loosely Coupled” – Social Organizations
 - “Organic” – Individuals
- Connecting observations/forecasts/warnings to “Key Decision Points” in all service areas
- How we measure success: determining intrinsic value of the forecast and IDSS

Hurricane Arthur Potential Storm Surge Mapping

‘Best Guess, Worst Case Scenario’

NHC Experimental Potential Storm Flooding Map
Tropical Storm ARTHUR (2014) Advisory 7
From 11 AM EDT Wednesday July 02 to 04 PM EDT Saturday July 05



The NWS must evolve to complete these goals

The Intrinsic Value of Forecasts



“First, it should be understood that forecasts possess no intrinsic value. They acquire value through their ability to influence the decisions made by users of the forecasts.”

“What is a Good Forecast? An Essay on the Nature of Goodness in Weather Forecasting”

– by Allan H. Murphy; Weather and Forecasting (June 1993)

Realizing Intrinsic Value

Intrinsic Value is realized through providing Impact-Based Decision Support Services (IDSS)

Generating forecasts and warnings + Connecting those forecasts/warnings with impacts = **IDSS**



The best hydrometeorological forecasting in the world

Practice, practice, practice!



Develop relationships/
know partner needs



Embed



Trust



“Ready, Responsive, Resilient”

January 2016 Blizzard & Costal Storm: Connecting All of the Pieces

Jan 15 - 18

Medium Range products begin identifying snowstorm threat for the end of next week

NWS offices begin briefing partners on potential storm



Jan 19

Confidence increasing

Partner Coordination/ Briefings



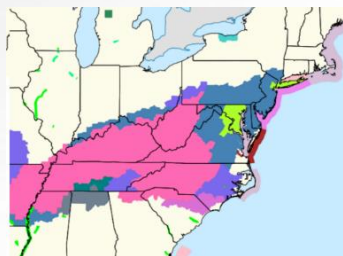
Media interviews

Jan 20

Partner Coordination/ Briefings

Media interviews

Blizzard Watches Issued



Jan 21

Fed./state/local govts make critical decisions before the snow begins

State of Emergency Declared:

- North Carolina
- Virginia
- West Virginia
- District of Columbia
- Maryland
- Pennsylvania
- New Jersey
- New York

Blizzard Warnings Issued

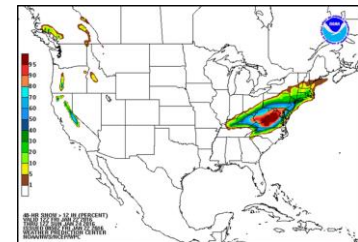
1 pm: Press Briefing



Jan 22

Snow begins in the Mid-Atlantic

Snow forecast adjusted to include NYC in Blizzard Warning



Schools/Govt Close
Flights Canceled
Roads Closed



Connecting All the Pieces

2013 Snowstorm

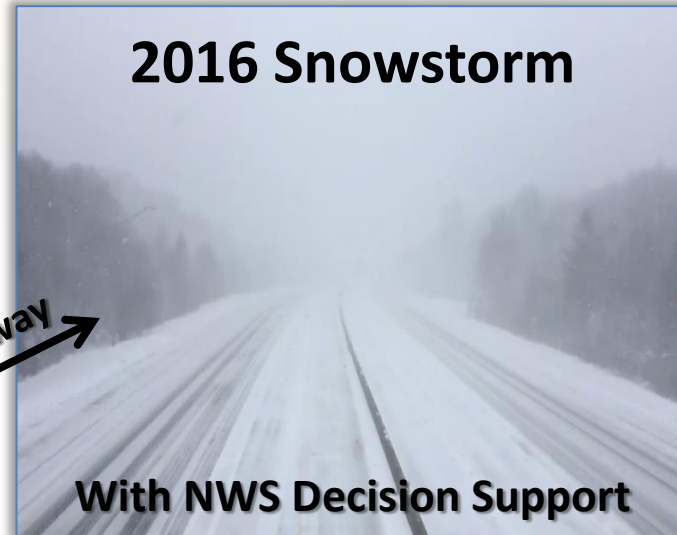


The Past

Pennsylvania Turnpike

Long Island Expressway

2016 Snowstorm



With NWS Decision Support



Without NWS Decision Support

Planning & Budget Structure Increases Transparency and enhances Service Delivery

Observations

Joe Pica

- A focused effort on sustaining & integrating all observations supporting the NWS mission and ensuring continuous situational awareness.

Central Processing

David Michaud

- Fully integrating the central and distributed computing system from central computer to AWIPS/AHPS

AFS

Andrew Stern

- Analyze, Forecast, Support includes all NWS forecast offices:
- Working toward “fully integrated field structure” providing consistent products & services
- Supports local/national IDSS, outreach, & social science integration (*nature of work will change*)

Dissemination

Luis Cano

- Better managed, reliable, centralized, and more responsive network, especially during high impact events.

STI

Ming Ji

- Accelerates numerical model advances, supports forecaster training/development
- Provides a centralized development environment to enable Research to Operations (R2O) & a visible “catcher’s mitt” for the rest of the research community interested in the R2O process (e.g., CSTAR, SOO/DOH ...)

Facilities

Deirdre Jones

- Make sustaining all of the NWS facilities a fundamental part of the NWS mission execution

FY2016 NWS President's Budget Request

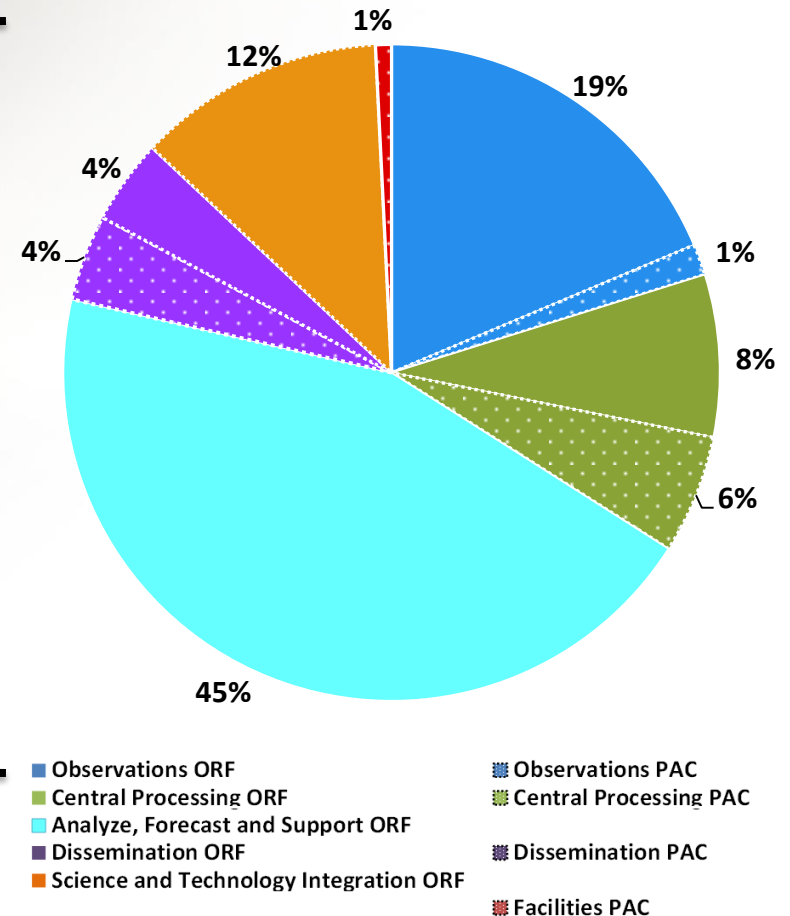
Composition by Portfolio

PPA	Funds*	Full Time Employees (FTE)
Observations ORF	204,876	804
Observations PAC	16,720	-
Central Processing ORF	87,902	134
Central Processing PAC	64,000	22
Analyze, Forecast and Support ORF	489,845	3,058
Dissemination ORF	46,743	82
Dissemination PAC	45,743	-
Science and Technology Integration ORF	134,197	517
Facilities PAC	8,650	-
TOTAL	1,098,878	4,617

* In thousands of dollars

Total Forecasters: 1,624

Funds Breakdown



NWS HQ & Field Organization

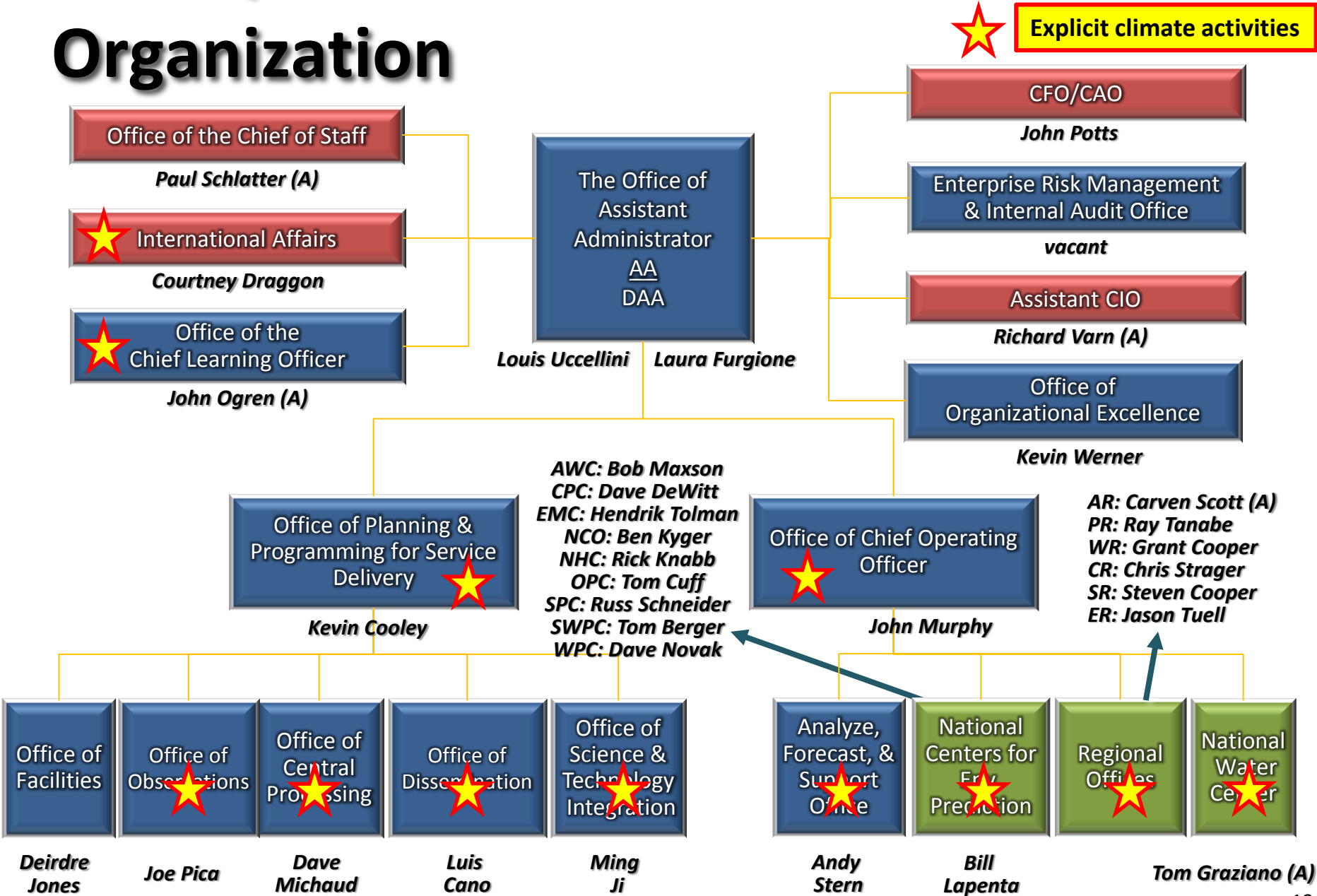
New HQ Office

Field Office

Existing HQ Office



Explicit climate activities



Within AFS: Climate Services Program

One of 11 National Service Programs

- Aviation Weather
- **Climate**
- Fire Weather
- Marine Weather
- Public Weather
- Severe Weather
- Space Weather
- Tropical
- Tsunami
- Water Resources
- Winter Weather

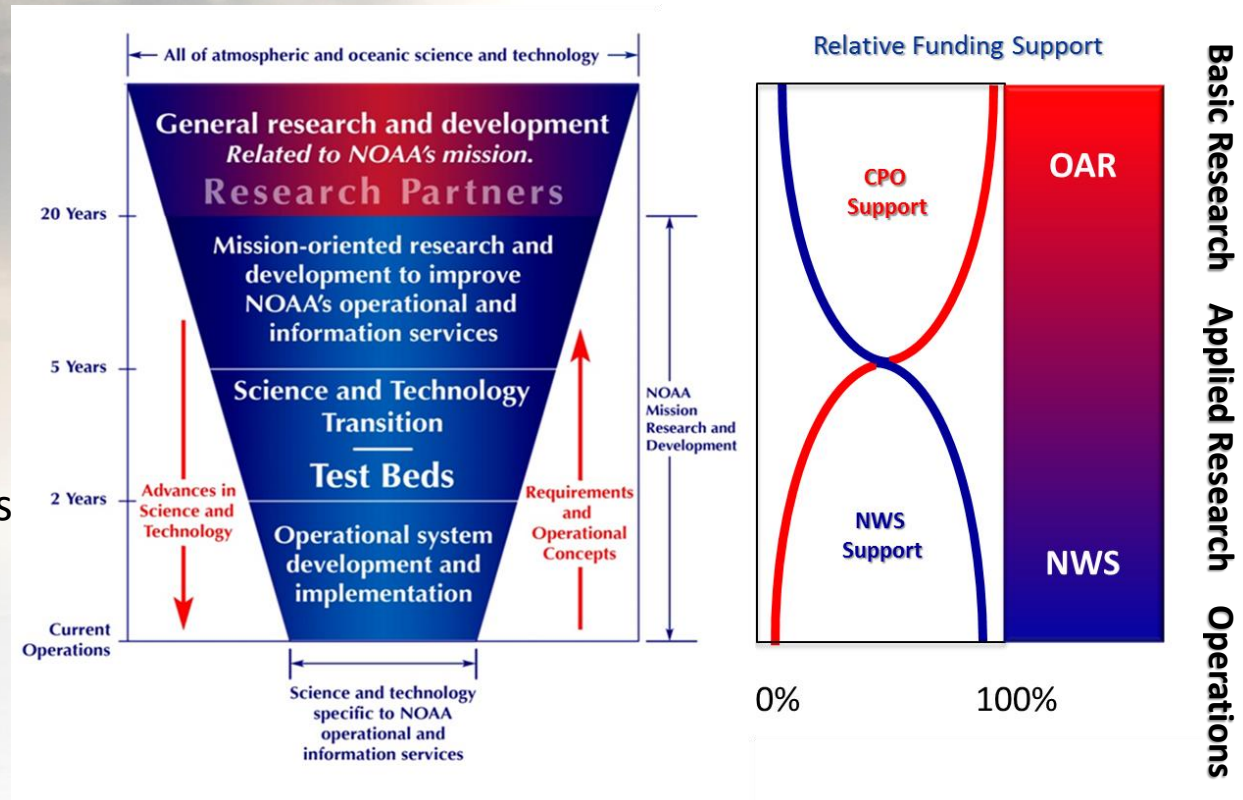
NWS Climate Services

End-to-end approach to climate services: from observations to prediction to user outreach at national and local levels

Within STI: Challenge of R2O and O2R

The R2O Funnel

- Path for transfer of scientific advances and technology into operational and information services
- NOAA operational requirements and concepts to inform research priorities atop the funnel



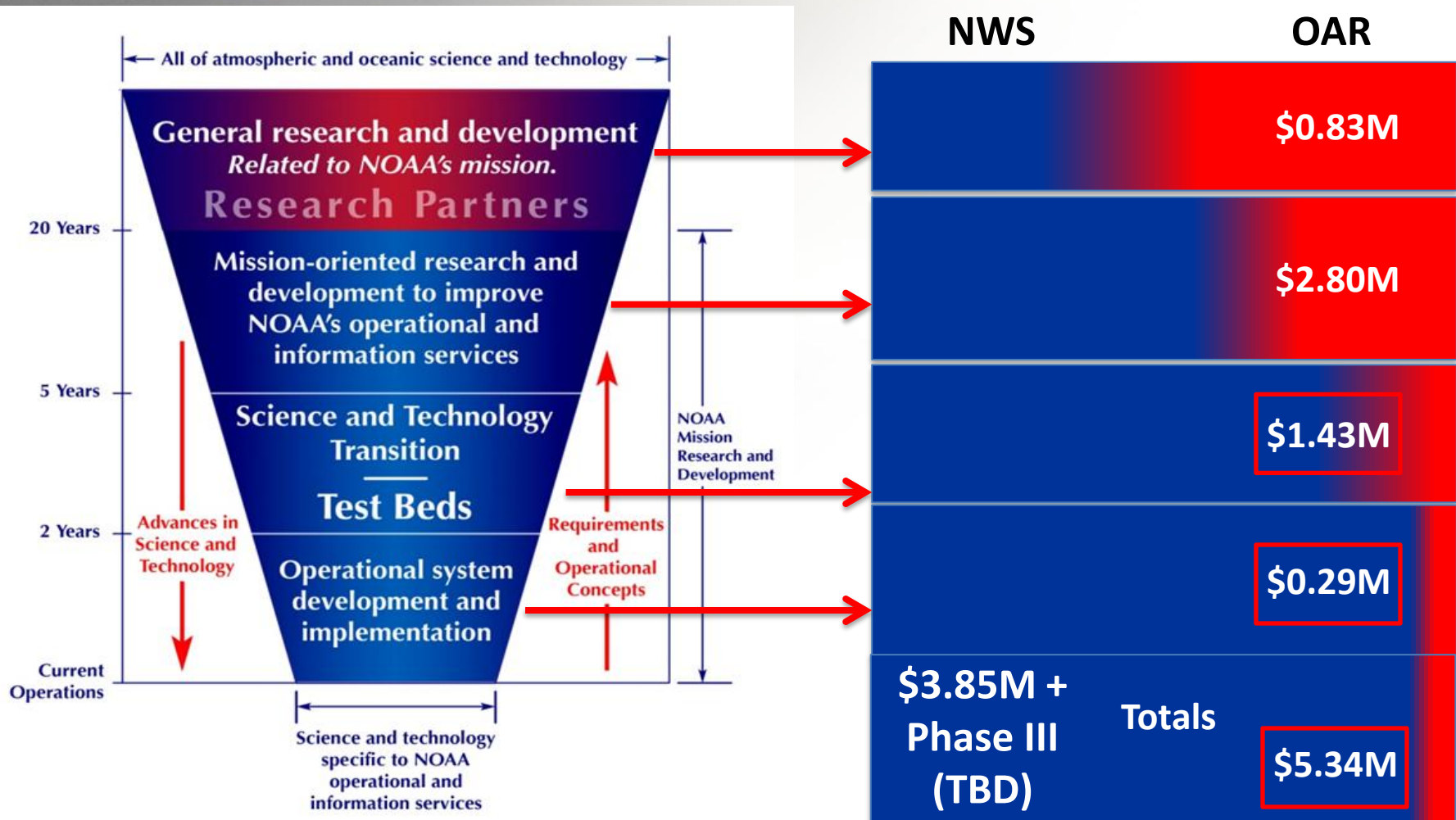
- Forms the basis of our MOU and Service Level Agreements (SLAs) with OAR for supporting our mission delivery research and transition needs

To accelerate R2O, need to support O2R and provide research access to operational observations, data assimilation and modeling system (Being applied to the development of the Next Generation Global Prediction System, NGGPS)

FY16 NWS-OAR

Service Level Agreement

- Includes 48 projects, based on OAR/CPO competitive and non-competitive funding
- Positions the Climate Test Bed as a major authority in the R2O/O2R paradigm



Climate Test Bed

Mission: Advancing operational climate monitoring, models, and prediction capabilities at subseasonal to seasonal and interannual timescales.

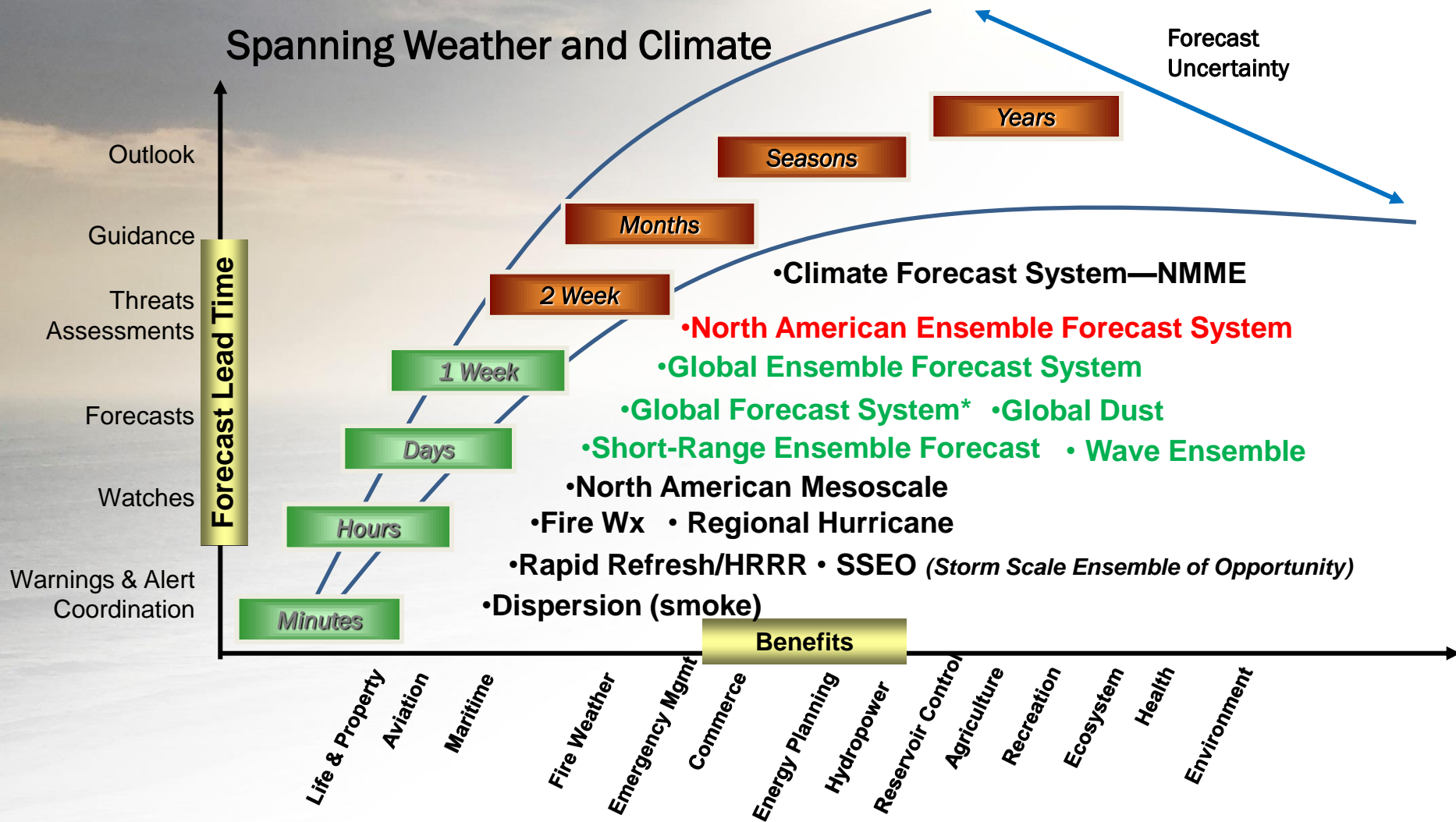
- Accelerate **research-to-operations (R2O)** transition to improve NCEP operational climate prediction
- Provide **operations-to-research (O2R)** support to the climate research community with access to operational models, forecast tools and datasets

Climate Test Bed Priorities:

1. Multi-model ensembles
2. Climate Forecast System (CFS) improvements
3. Climate forecast tools and products
4. Climate monitoring tools and products (**new**)

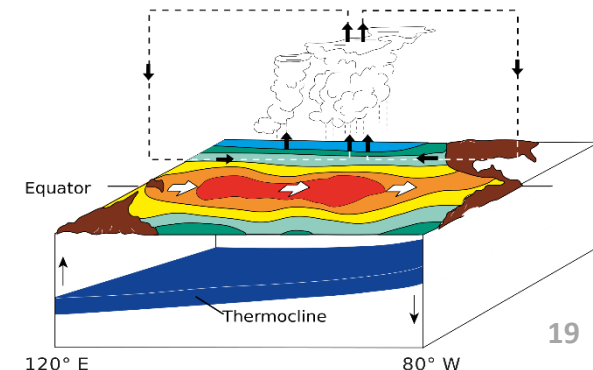
New website: <http://www.nws.noaa.gov/ost/CTB>

Seamless Suite of Forecasts: Increasingly Based on Multi-Model Ensembles

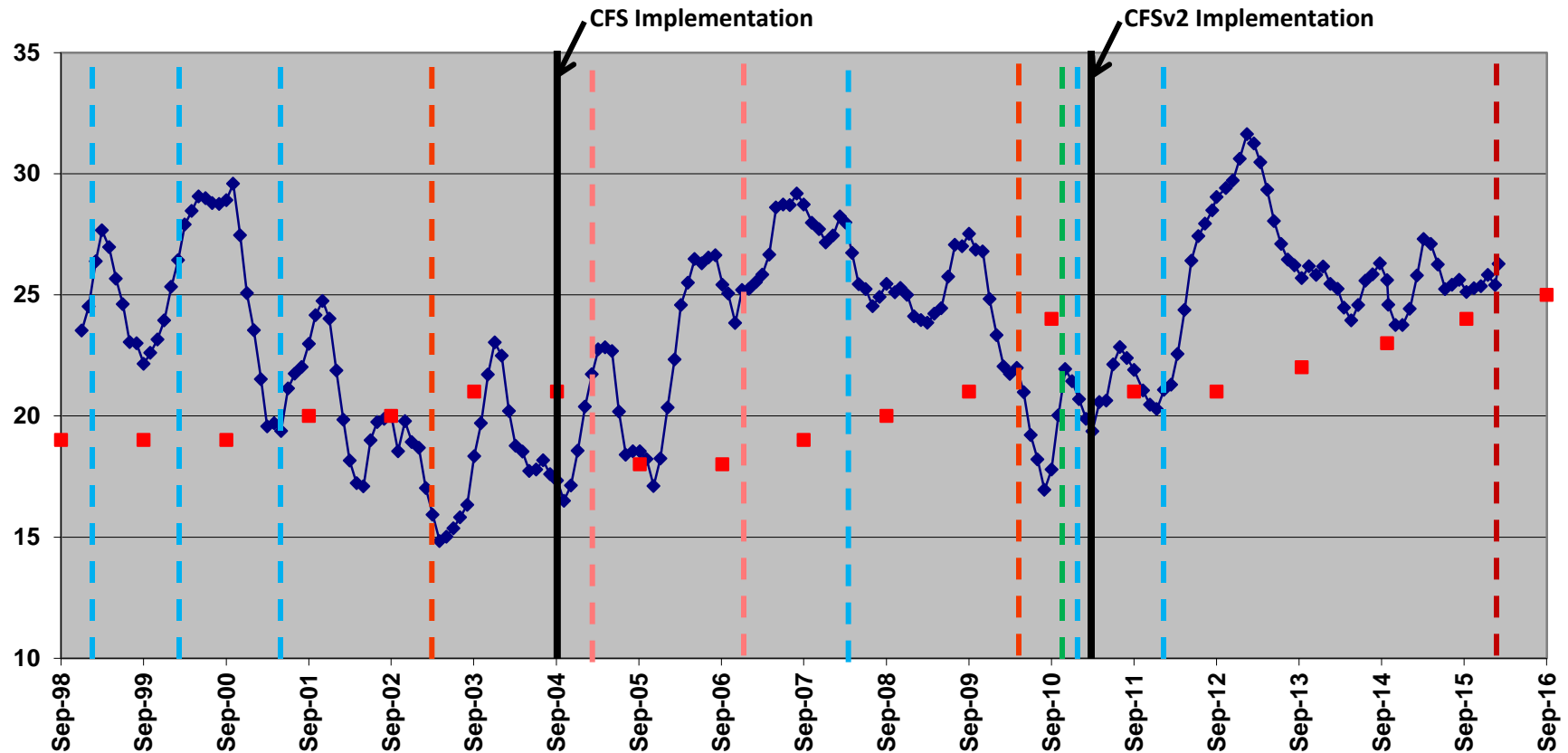


Climate Forecast System (CFS)

- Numerical model that couples atmosphere, ocean, land and sea-ice components
- Provides sub-seasonal (multiple weeks) to seasonal (~9 months) forecasts
- Focus on prediction of US temperature and precipitation, as well as large-scale features such as MJO and ENSO (El Niño/La Niña cycles) tied to various weather patterns over the U.S. and worldwide
- Future: Include aerosol dust/chemistry and ocean wave model components; Incorporate new observational data sets for all six components



48 Month Running Mean of Heidke Skill Score Seasonal Temperature



Each point is a 48 month average

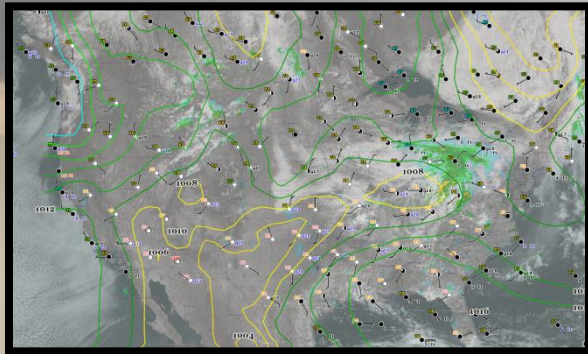
■ GPRA Goal
■ Actual Skill

--- El Niño winters (darker=stronger)
--- La Niña winters
--- Significant -ve AO

“The Grand Challenge”

Shapiro et al (BAMS, 2010)

Addressing the weather/climate linkage



Week 3-4

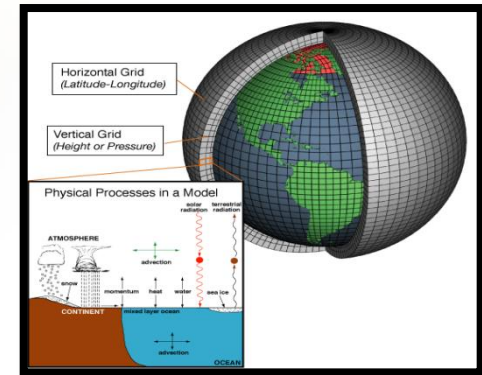
Weather Modeling

Hours to 1-2 weeks

Highly sensitive to
initial conditions

**SKILL
GAP**

**Needs
both**



Climate Modeling

Seasonal to Decadal

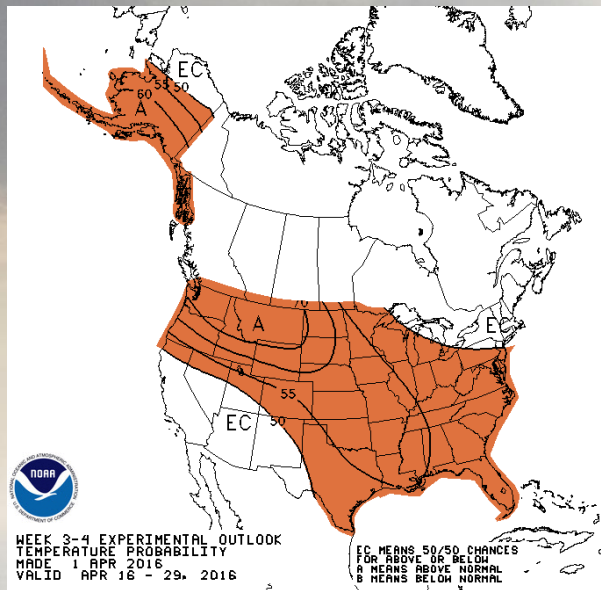
Sensitive to boundary
conditions related to
coupling of ocean, land,
ice, and atmosphere

Presented to OSTP/OMB/White House in summer 2014 as a major
forecast imperative

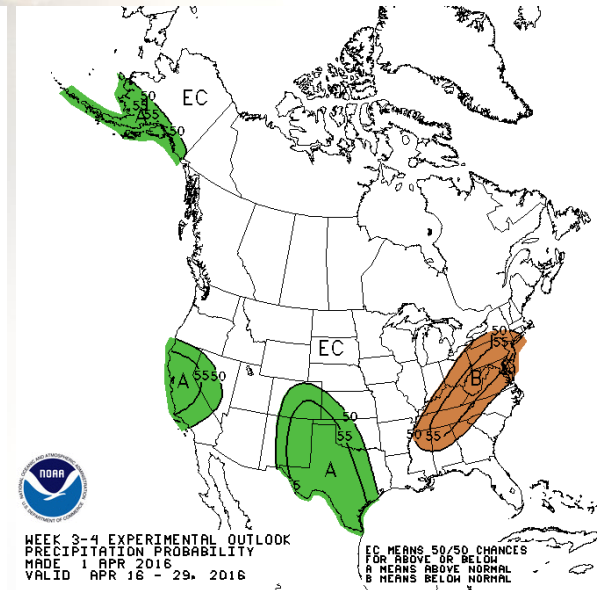
CPC Update

Week 3-4 Forecast and Verification for April 16 – 29

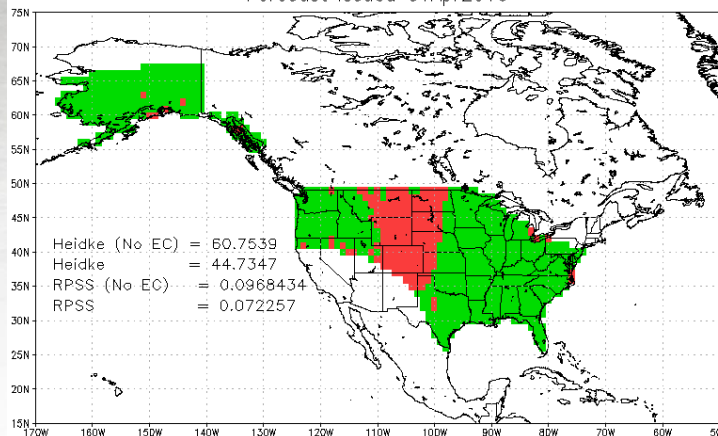
Temperature
Forecast



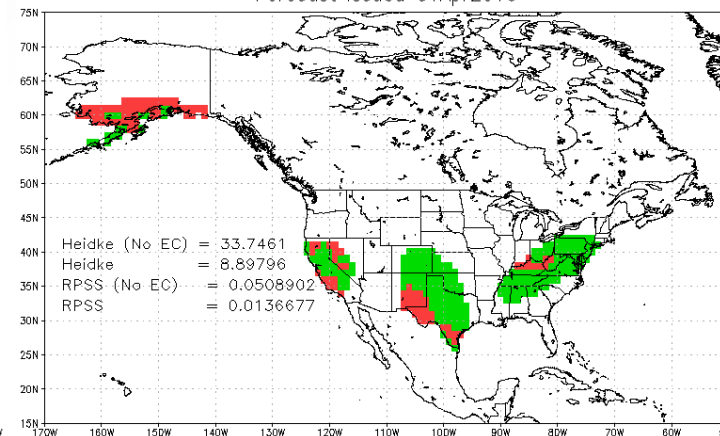
Precipitation
Forecast



Weeks 3/4 Temperature Hit/Miss
Forecast Issued 01Apr2016

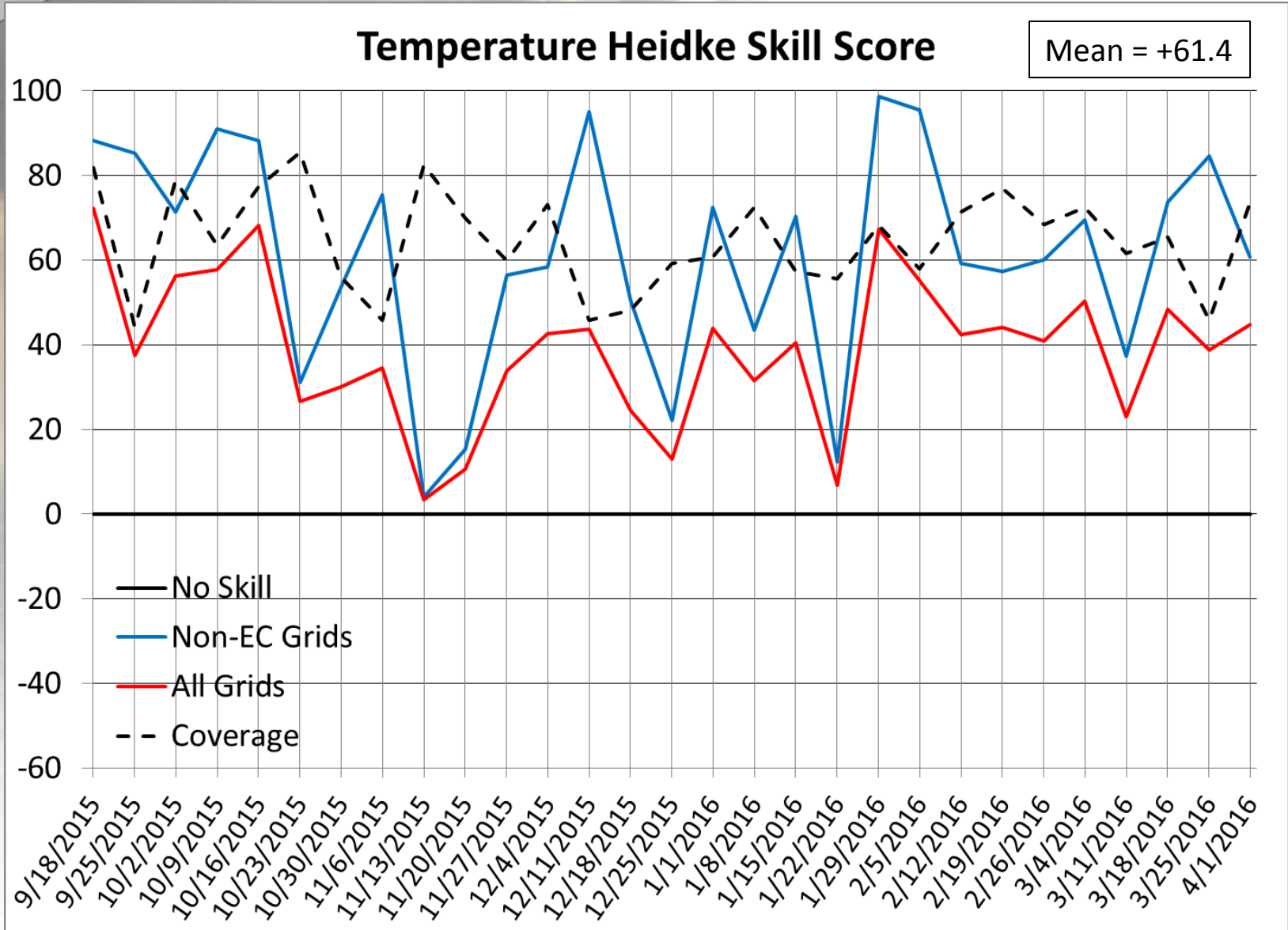


Weeks 3/4 Precipitation Hit/Miss
Forecast Issued 01Apr2016



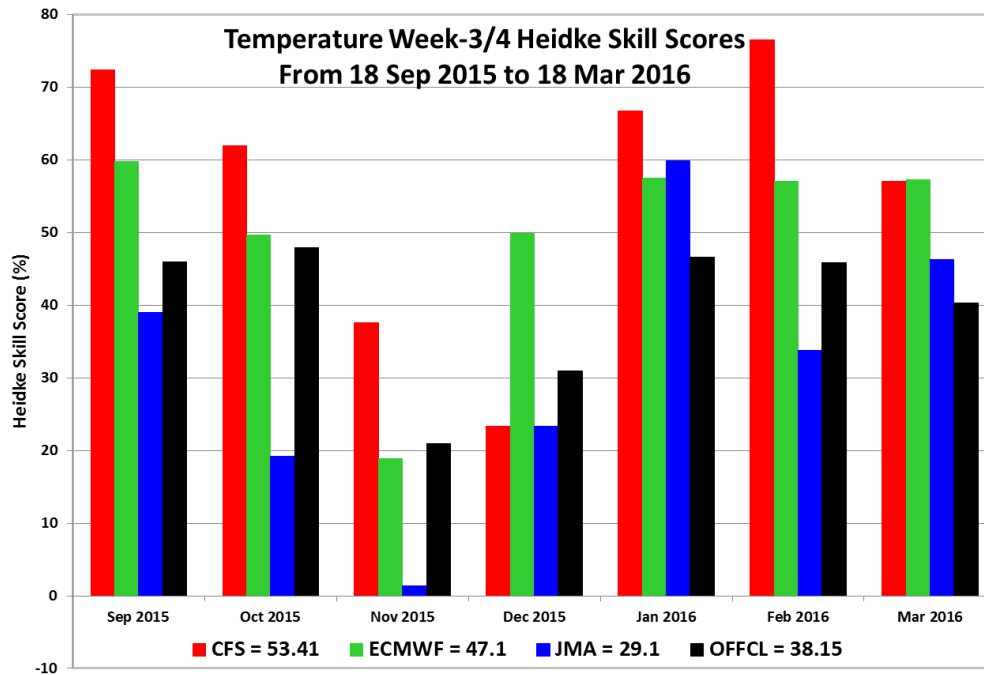
Precipitation
Verification

Temperature Verification

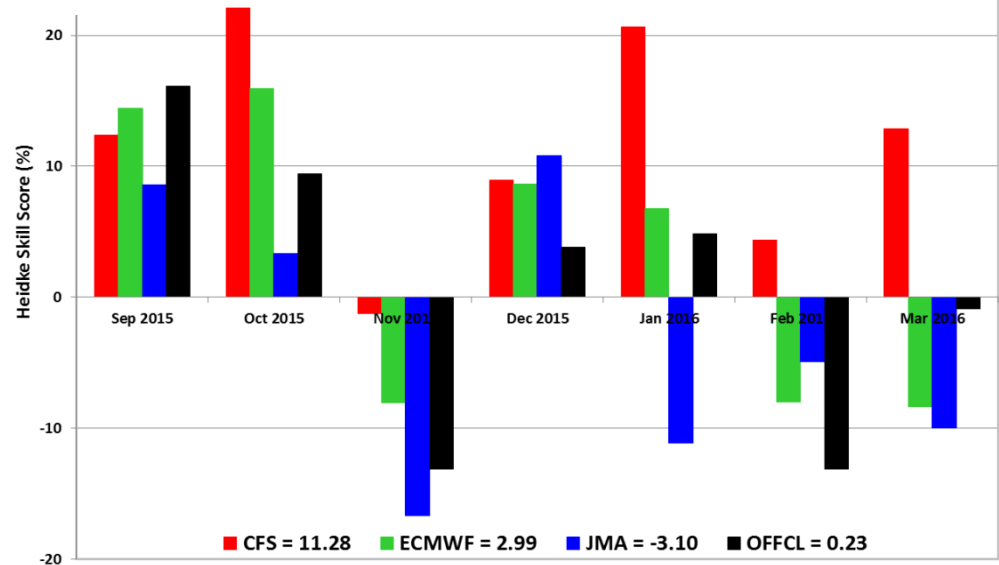


How is CFS doing?

Temperature Week-3/4 Heidke Skill Scores
From 18 Sep 2015 to 18 Mar 2016



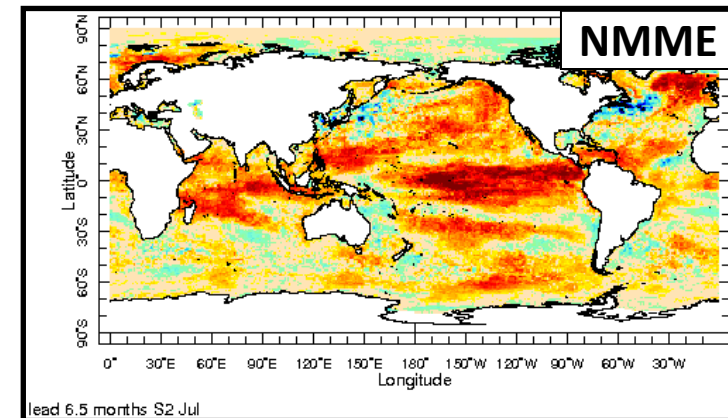
Precipitation Week-3/4 Heidke Skill Scores
From 18 Sep 2015 to 18 Mar 2015



High Priority

Cross-NOAA Activities

- Addresses the Grand Challenge/climate-weather linkage
 - Implement NMME seasonal forecast system
 - Incorporate “Next Generation Model” into CFS
 - Incorporate updated reanalysis/reforecasts
- Linkages to other areas/applications
 - Water
 - Ecological forecasts
 - Health vectors/related decisions
 - Fisheries



Ranked probability skill scores of 6.5-month sea surface temperature forecasts

Grand Challenge: Unified Global Coupled System (UGCS) for Weather, Water and Climate Prediction

- UGCS will include fully-coupled components of the Earth system, namely Atmosphere, Land-Hydrology, Ocean, Sea-Ice, Waves & Aerosol, both for data assimilation and model forecasts
- Use NEMS/ESMF software
- **Atmosphere** will comprise of a new dynamic core, new physics, higher resolution in the horizontal and vertical, accompanied by an advanced 4D EnVAR data assimilation system
- **Ocean** component will be MOM6 and HYCOM model systems with updated physics and bio-geochemistry and an ensemble based coupled data assimilation system
- **Land-Hydrology** component will be Noah Land model with upgrades to land surface physics and an upgraded ensemble based Land Information System that assimilates new data sources
- **Sea-Ice** component will be CICE and SIS2 model systems with an ensemble-based coupled sea-ice data assimilation system for sea-ice cover and thickness
- **Wave** component will be Wavewatch III that will be fully coupled to the atmosphere and ocean, with a new ensemble-based coupled data assimilation for assimilating significant wave height observations, etc
- **Aerosol** component will be GOCART and will also have a ensemble-based coupled data assimilation to incorporate AOD and other sources of data
- Will unify the GFS, GEFS and CFS models under a single unified modeling system for:
 - Weather (GFS):** ~10 days, 10 km, 128 levels, 3 year reanalysis & hindcasts, implement every year
 - Sub-seasonal (GEFS):** ~45 days, 30km, 128 levels, 20 year reanalysis & hindcasts, implement every 2 years
 - Seasonal (CFS):** ~12 months, 50km, 128 levels, 40 year reanalysis & hindcasts, implement every 4years

National Water Center

University of Alabama – Tuscaloosa, AL



VISION: Scientific excellence and innovation driving water prediction to support decisions for a water resilient nation

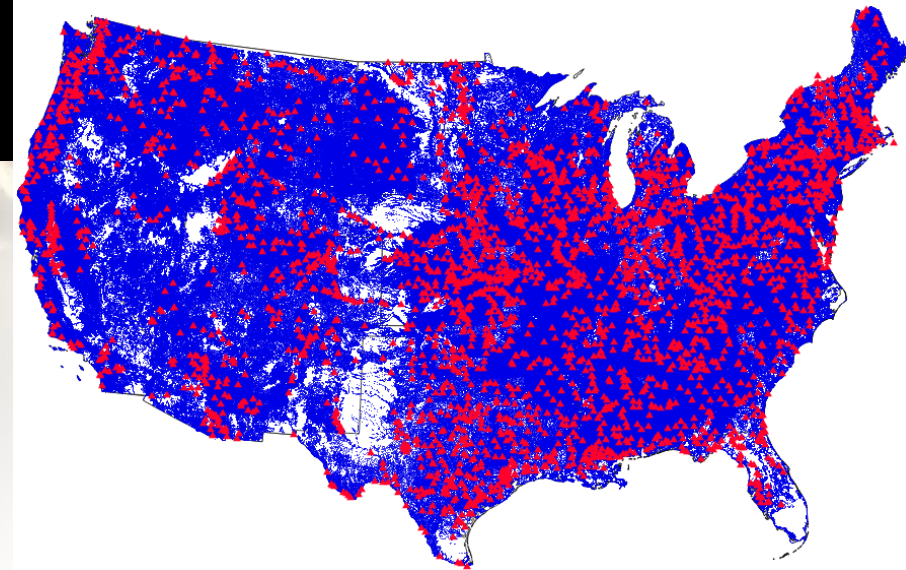
BENEFITS:

- State-of-the science modeling for global to street level predictions (*from 6,000 forecast locations to 2.7 million stream reaches*)
- Operations Center to establish common operating picture within NOAA and among water agencies; decision support for floods to droughts (*flood mapping to street level*)
- Proving ground to accelerate research to operations; partnerships with research communities (*e.g. CHUASI, National Flash Flood Interoperability Experiment*)
- Data integration and service backup

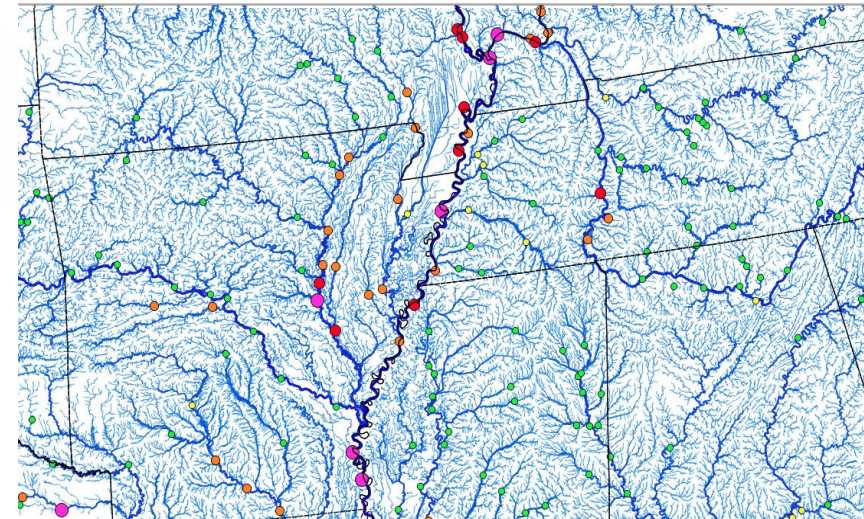
National Water Model (NWM)

IOC Experimental Output (FY16)

- **Hydrologic Output**
 - River channel discharge and velocity at 2.7 million river reaches
 - Surface water depth and subsurface flow (250 m CONUS+ grid)
- **Land Surface Output**
 - 1km CONUS+ grid
 - Soil and snow pack states
 - Energy and water fluxes
- **Data Services**
 - Public-facing NWC website
 - Data feed to River Forecast Centers
 - NOMADS data service



Current NWS AHPS locations (**red**)
NWM output locations (**blue**)

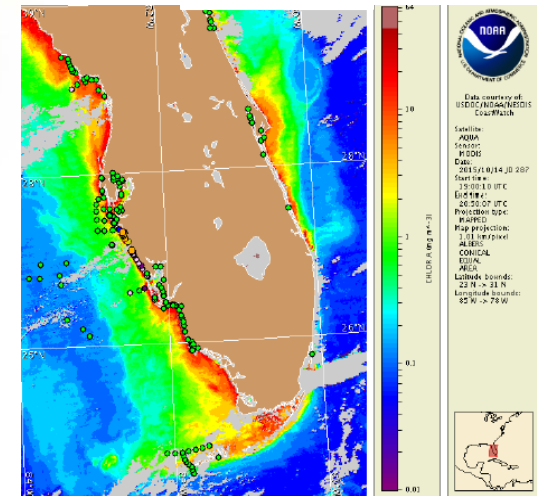


Current NWS River Forecast Points (circles)
Overlaid with NWM Stream Reaches

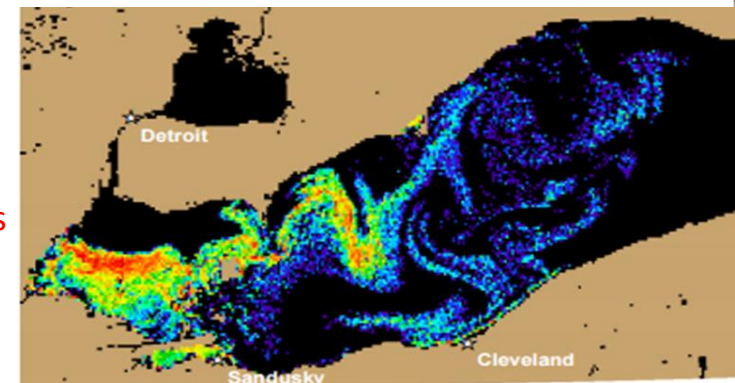
One NOAA Collaboration for Ecological Forecasting

- **NOS** models run on NOAA/NWS operational supercomputer
- HAB, Hypoxia, Vibrio prediction in Gulf of Mexico **led by NOS**
- HAB: Real-time prediction in Great Lakes by **NOS/OAR-GLERL**
- The 5th NWS Strategic Goal “Enable environmental forecast services supporting healthy communities & ecosystem”:
 - **Gulf of Mexico** (status: operational)
 - **NWS:** WFOs Tampa and, new in 2015, Miami and Key West, capable of issuing Beach Hazard Statements for high respiratory irritation from HAB
 - **Lake Erie** (status: experimental)
 - **NWS:** WFO Cleveland hosts Lake Erie HAB web page;
 - **New in 2016:**
 - **WFO CLE** provides decision support [dashboard](#) to NOS HAB analysts
 - **OHRFC** to provide HAB analysts CFS 45-day flow forecasts for 2 points on Maumee River
 - **WFO CLE/OHRFC** provide River Forecasting 101 webinar for Ohio state agencies, GLERL, and NOS HAB analysts

Source: NESDIS;
10/15/15



Source: NESDIS;
9/8/15



Success is based on TRUST and recognition that we all could gain in serving this predictive need



Summary

- Working towards building a Weather-, Water- and Climate-Ready Nation
- NWS working closely with all NOAA line offices (especially OAR/CPO) to establish a framework for effective R2O/O2R and improved service delivery
- Climate services programs (collocated within AFS) touch a large portion of the NWS management infrastructure
- Many strategic opportunities exist (especially the “grand challenge”) based on a unified global-coupled system (UGCS) for weather, water and climate prediction, including application to health vectors, fisheries and other strategic areas